The North Atlantic Oscillation as a driver of multidecadal variability of the AMOC, the AMO, and Northern Hemisphere climate

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We use suites of simulations with coupled ocean-atmosphere models to show that multidecadal changes in the North Atlantic Oscillation (NAO) can drive multidecadal changes in the Atlantic Meridional Overturning Circulation (AMOC) and the Atlantic Multidecadal Oscillation (AMO), with associated hemispheric climatic impacts. These impacts include rapid changes in Arctic sea ice, hemispheric temperature, and modulation of Atlantic hurricane activity. We use models that incorporate either a fully dynamic ocean or a simple slab ocean to explore the role of ocean dynamics and ocean-atmosphere interactions.

A positive phase of the NAO is associated with strengthened westerly winds over the North Atlantic. These winds extract more heat than normal from the subpolar ocean, thereby increasing upper ocean density, deepwater formation, and the strength of the AMOC and associated poleward ocean heat transport. This warming leads to a positive phase of the AMO. The enhanced oceanic heat transport extends to the Arctic where it causes a reduction of Arctic sea ice. Large-scale atmospheric warming reduces vertical wind shear in the tropical North Atlantic, creating an environment more favorable for tropical storms.

We use models to further show that observed multidecadal variations of the NAO over the 20th and early 21st centuries may have led to multidecadal variations of simulated AMOC and the AMO. Specifically, negative NAO values from the late 1960s through the early 1980s led to a weakened AMOC/cold North Atlantic, whereas increasing NAO values from the late 1980s through the late 1990s increased the model AMOC and led to a positive (warm) phase of the AMO. The warm phase contributed to increases in tropical storm activity and decreases in Arctic sea ice after the mid 1990s. Ocean dynamics are essential for translating the observed NAO variations into ocean heat content variations for the extratropical North Atlantic, but appear less important in the tropical North Atlantic. The observed AMO has substantial SST amplitude in both the tropical and extratropical North Atlantic. These results suggest that additional factors, such as cloud feedback, dust feedback, and anthropogenic radiative forcing, may play a crucial role for the tropical expression of the AMO.

Keywords: North Atlantic Oscillation, climate, ocean, AMOC

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